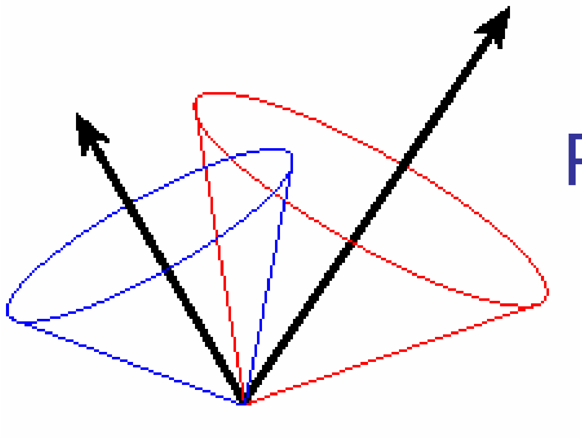
DØ Jet Energy Scale and Inclusive Jet Cross Section



Norm Buchanan

(for the DØ Collaboration)

Florida State University

July 4, 2005

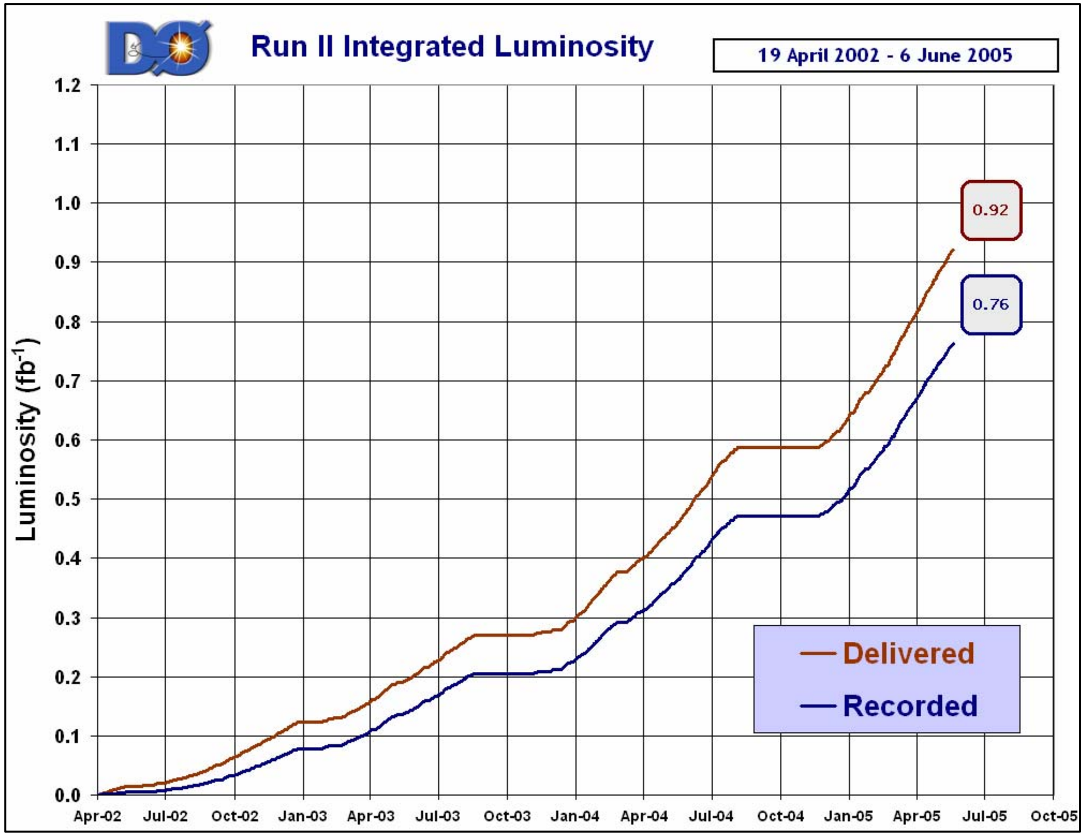
HCPS05 July 4 – July 9 2005

Les Diablerets, Switzerland

Outline

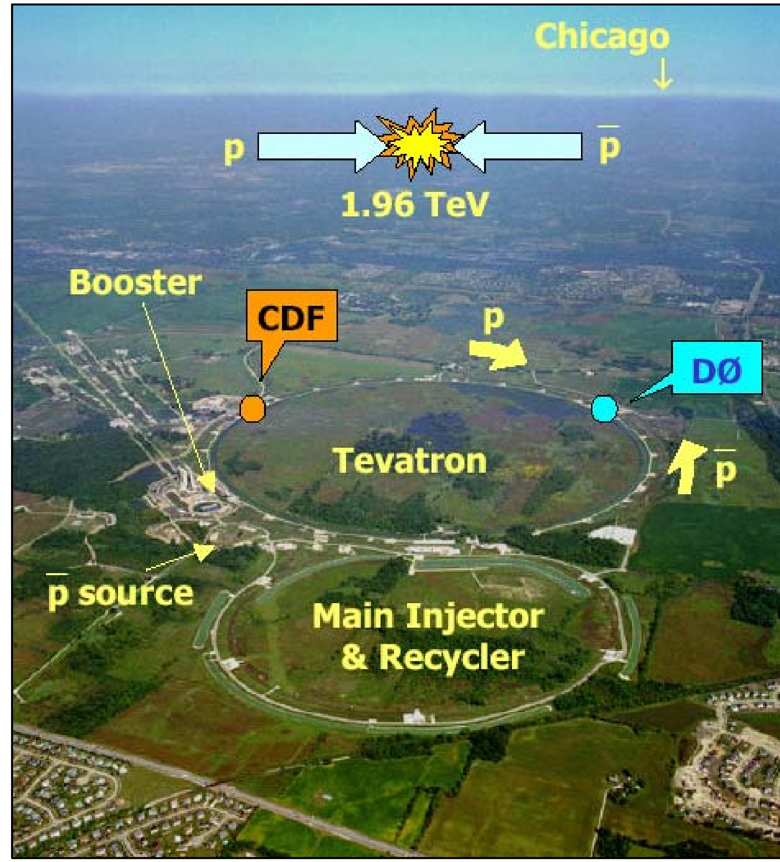
- Tevatron and DØ Introductions
- DØ Calorimeter
- Jet Energy Scale
- Inclusive Jet Cross Section
- Conclusions

Fermilab Tevatron Collider



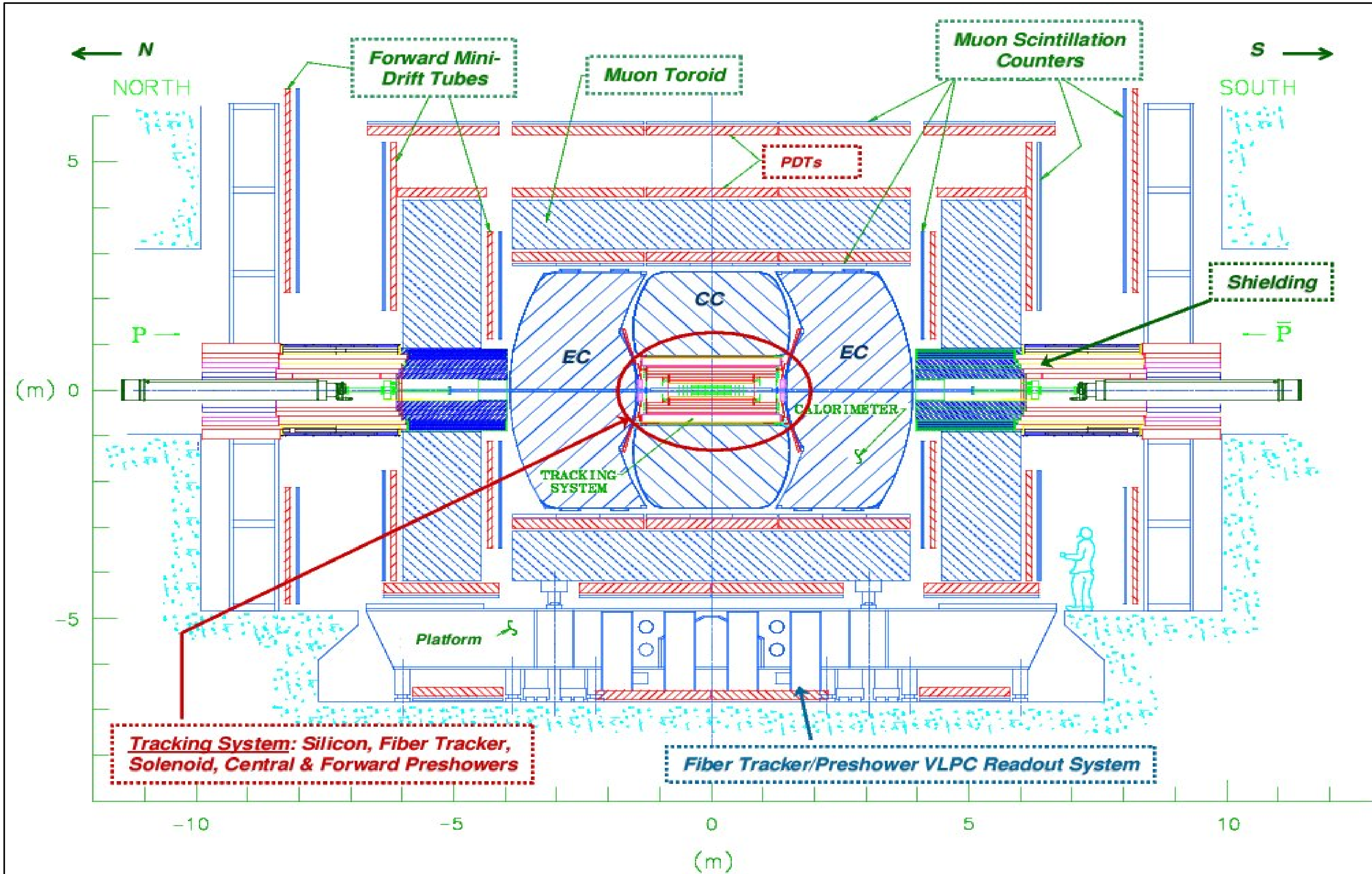
Run I - ~ 0.1 fb^{-1} $\sqrt{s} = 1.8\text{TeV}$

Run II (2005) - ~1 fb^{-1} $\sqrt{s} = 1.96\text{TeV}$



~1fb^{-1} delivered and ~0.8fb^{-1} recorded

DØ Detector



N
NORTH
Forward Mini-Drift Tubes
Muon Toroid
Muon Scintillation Counters
S
SOUTH
PDTs
Shielding
P
P̄
CC
EC
EC
CALORIMETER
TRACKING SYSTEM
Platform
Tracking System: Silicon, Fiber Tracker, Solenoid, Central & Forward Preshowers
Fiber Tracker/Preshower VLPC Readout System
5
(m) 0
−5
−10
−5
0
5
10
(m)

DØ Calorimeter

Upgraded calorimeter for Run II

- 396 ns bunch separation – faster readout and triggering
- additional material in front of calorimeter

- Hermetic coverage: $|\eta| < 4.2$
- Fine segmentation:

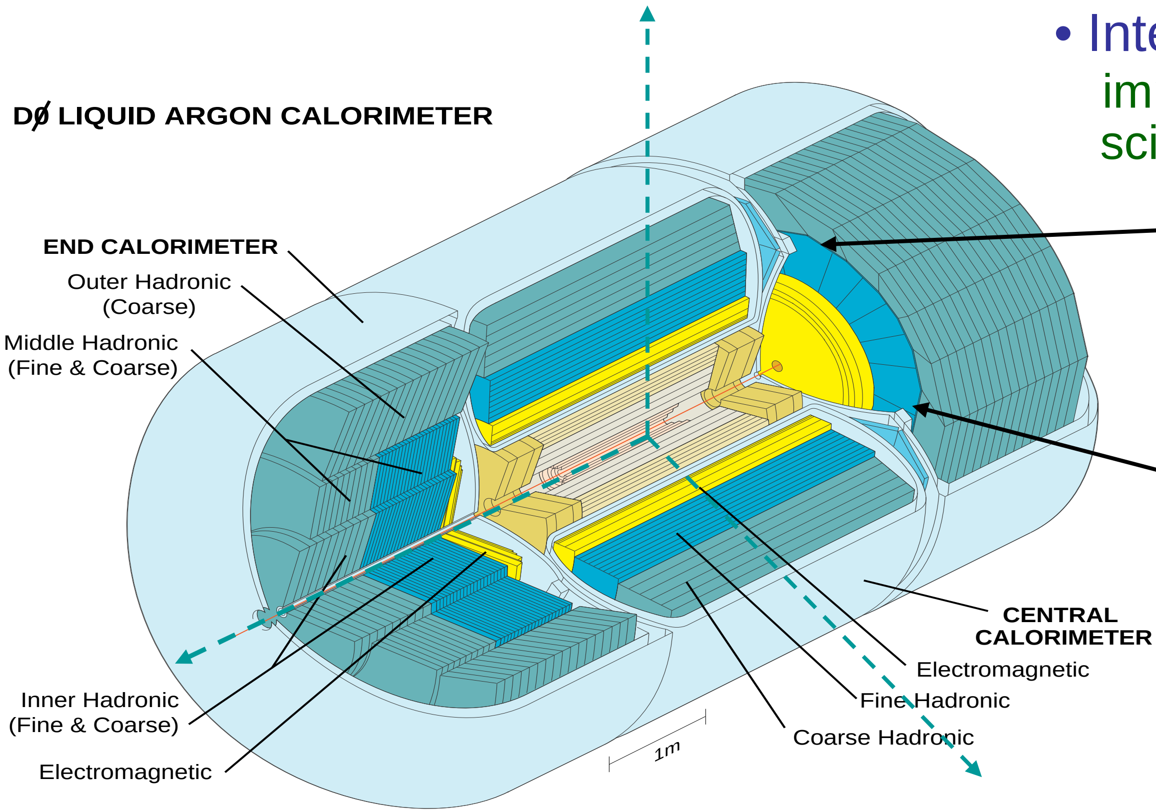
  $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$

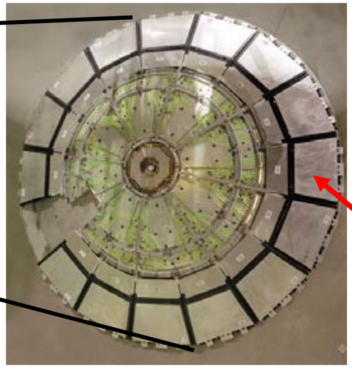
  (shower max: 0.05×0.05)

- Inter-cryostat detector (ICD):

  improves coverage $1.1 < \eta < 1.4$

  scintillator-based



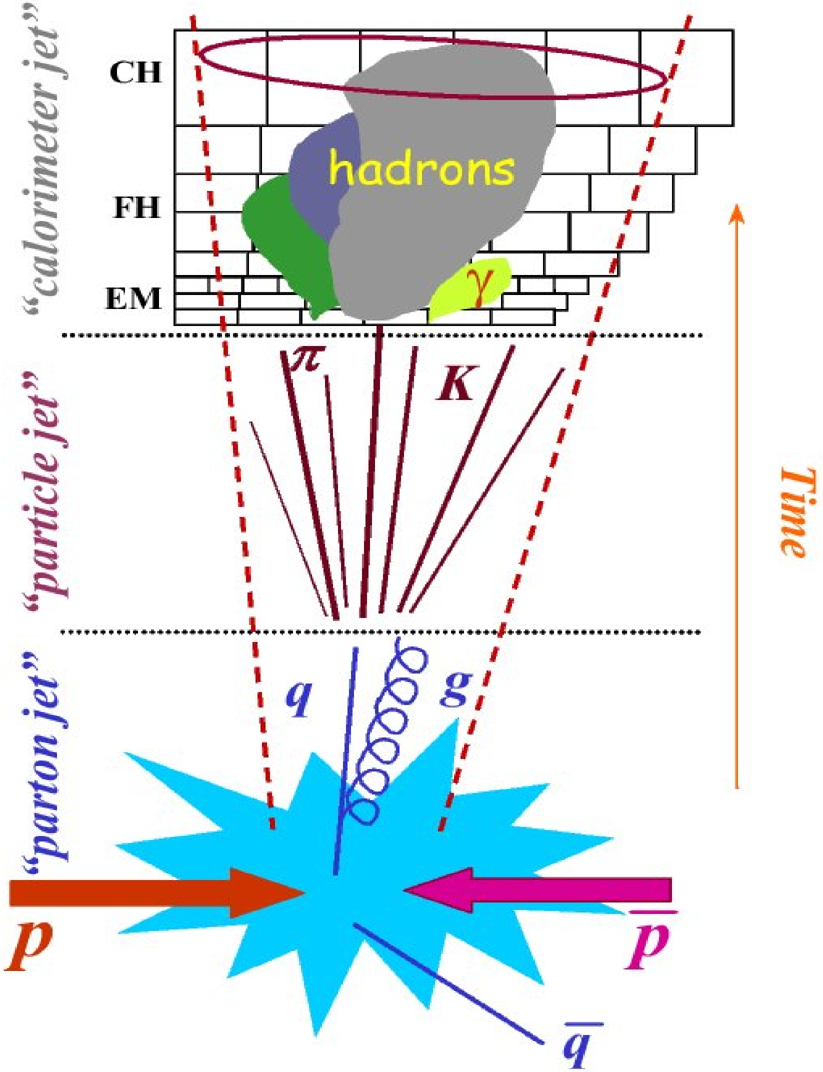


ICD

pseudo-rapidity η

$$\eta = -\log\left(\tan\frac{\theta}{2}\right)$$

Jets



Calorimeter Jet

- jet properties measured
  - transverse energy
  - shower shape

Particle Jet

- following hadronization
- particle jets
- particles along parton direction

Parton Jet

- parton hard scattering
- parton showering

Run II Cone Algorithm

- Seeds collected within cone R_{cone}<0.7

MC: stable particles
Detector: calorimeter towers
pQCD: partons

$$R_{cone} = \sqrt{(\Delta\varphi)^2 + (\Delta y)^2}$$

- 4-vector scheme: rapidity y rather than η
  p_T rather than E_T

$$y = \frac{1}{2}\ln\left(\frac{E+p_z}{E-p_z}\right)$$

- For each seed (above threshold): find p_T-weighted centroid within R_{cone}=0.7 and use as next seed until stable solution
- Midpoints between solutions become seeds ⟶ infrared safe
- If jets overlap: combine if overlap is large, split otherwise
- Only jets with E_T > 8 GeV are kept
- Result – unique solutions that address overlaps

Jet Energy Scale

Must correct measured detector jet energy to particle jet energy

$$E_{jet}^{ptcl} = \frac{E_{jet}^{meas} - E_{off}}{R_{jet} \times S_{cone}}$$

E_{off}: Offset - not associated with hard scatter

U noise, pile-up, underlying event, etc…

F(L, R, η)

R_{jet}: Response – calorimeter response to jet

determined from E_T balance in γ+jet events

EM scale determined using $Z \rightarrow ee$

F(measured jet energy, η)

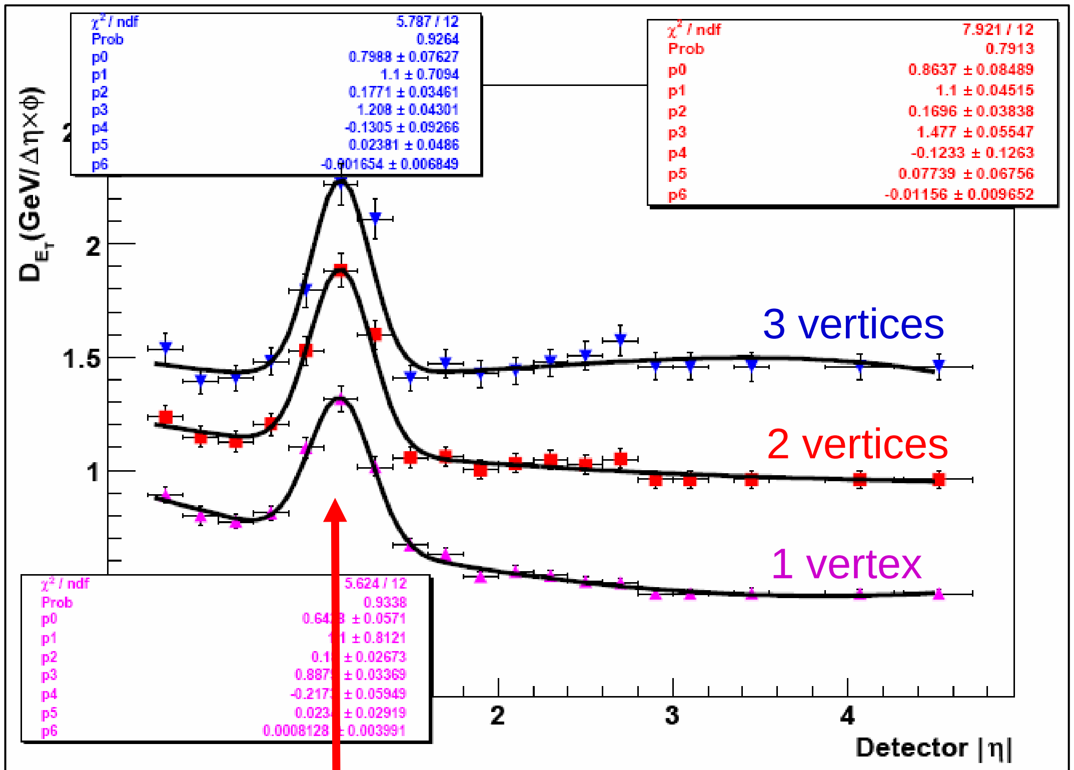
S_{cone}: Shower losses

fraction of energy contained in algo cone

F(R, measured jet energy, η)

Offset

Transverse energy density D_{E_T} (averaged over $\Delta\eta$ rings)



Use zero bias and min bias events

ZB – electronic and U noise

MB – underlying event contribution

For ZB – veto on L0 counters

Use E_T density from ZB to get contribution from underlying event

D_E scales with # primary vertices

Once # primary vertices fixed only small dependence on L.

Error bars account for statistics, luminosity and ϕ uncertainties

due to ICD and CH weight factors

Jet Response

Deposited energy ≠ measured energy

Not perfectly compensating

Dead material, fluctuations between modules, etc…

Missing E_T projection method

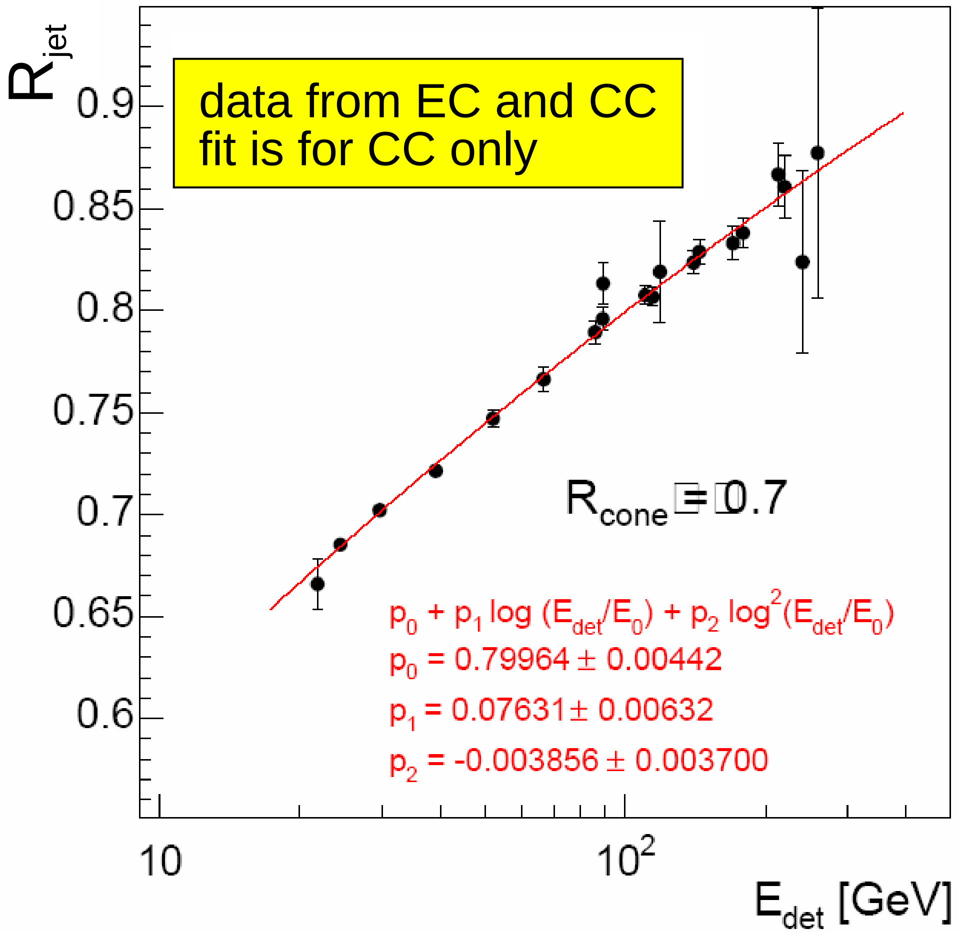
use p_T imbalance in γ+jet events

$$\boxed{\vec{E}_{T\gamma} + \vec{E}_{T\mathrm{recoil}} = 0 \quad \text{(ideal)}}$$

$$\boxed{R_\gamma \vec{E}_{T\gamma} + R_{\mathrm{recoil}} \vec{E}_{T\mathrm{recoil}} = -\vec{\not{E}}_T \quad \text{(real)}}$$

after em calibration from Z mass, $R_\gamma = 1$

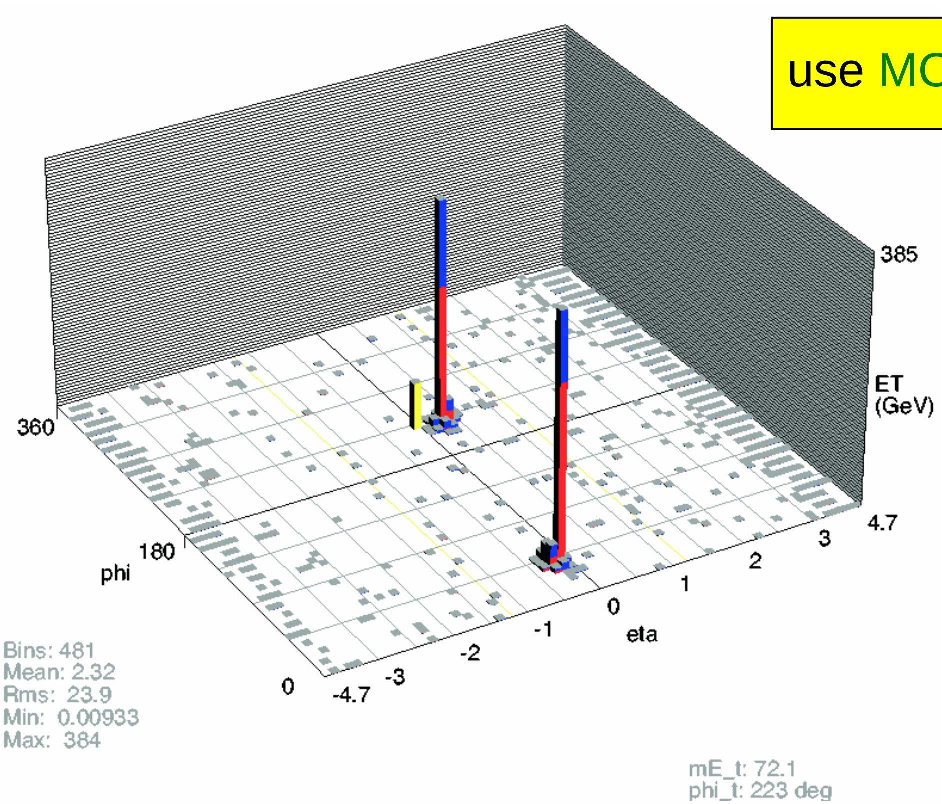
$$\boxed{R_{\mathrm{recoil}} = 1 + \frac{\vec{n}_{T\gamma} \cdot \vec{\not{E}}_T}{E_{T\gamma}}}$$



choose back-to-back events $R_{jet} = R_{recoil}$

Out-of-Cone Showering

Shower particles can scatter out of cone and non-shower particles into cone



Run 178796 Event 67972991 Fri Feb 27 08:34:03 2004

use MC, γ+jet and di-jet events

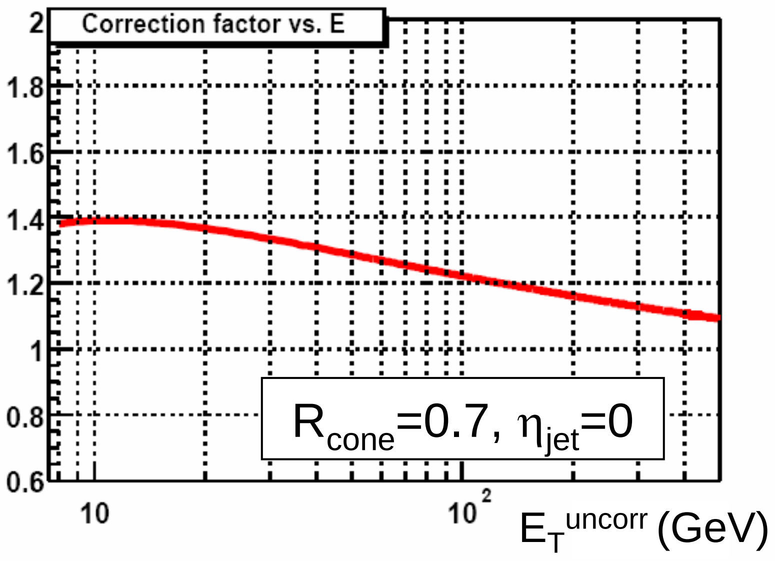
Study energy flow as function of distance from jet axis r.

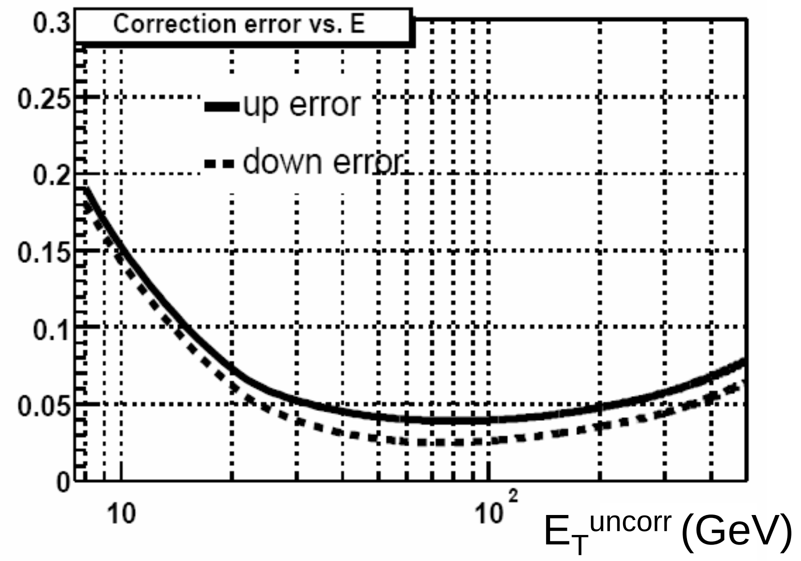
$$r = \sqrt{(\eta - \eta_{jet})^2 + (\varphi - \varphi_{jet})^2}$$

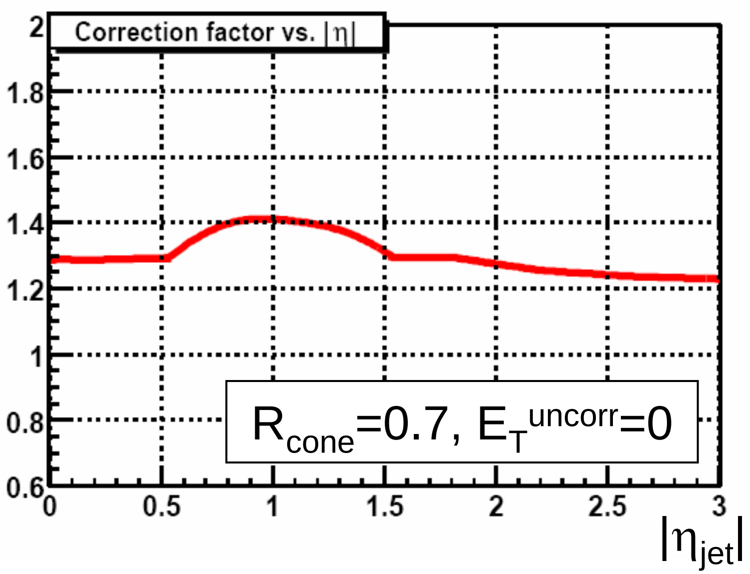
	R=0.7	R=0.5
central	0.99	0.92
ICR	0.96	0.89
forward	0.94	0.85

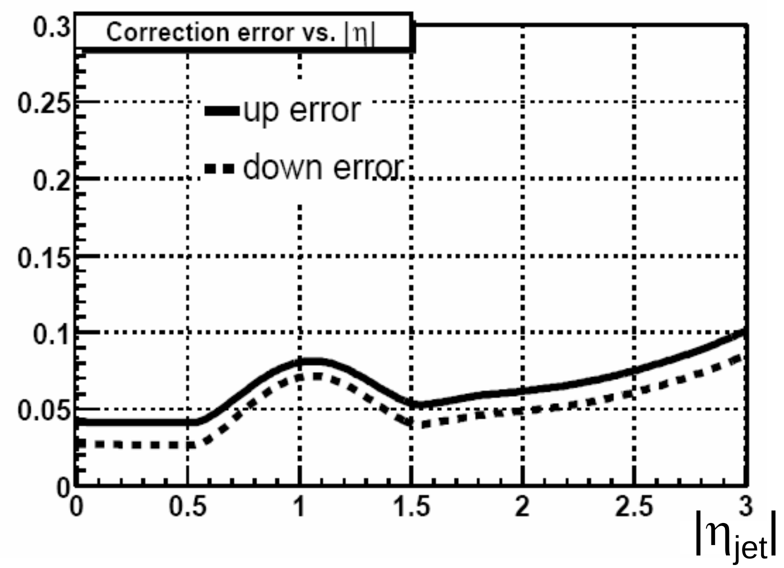
S_{cone} (systematic error ~5%)

Total Jet Energy Correction





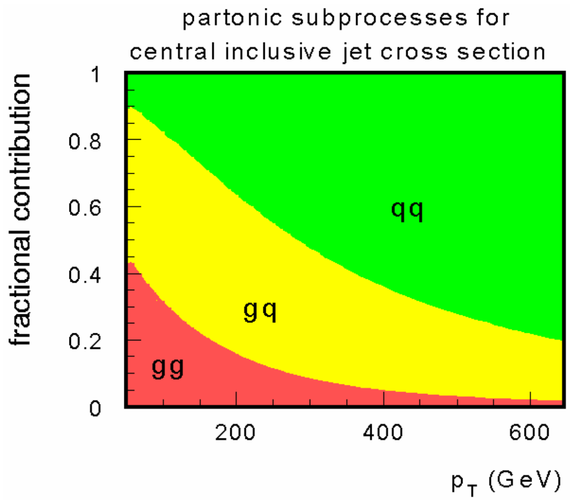




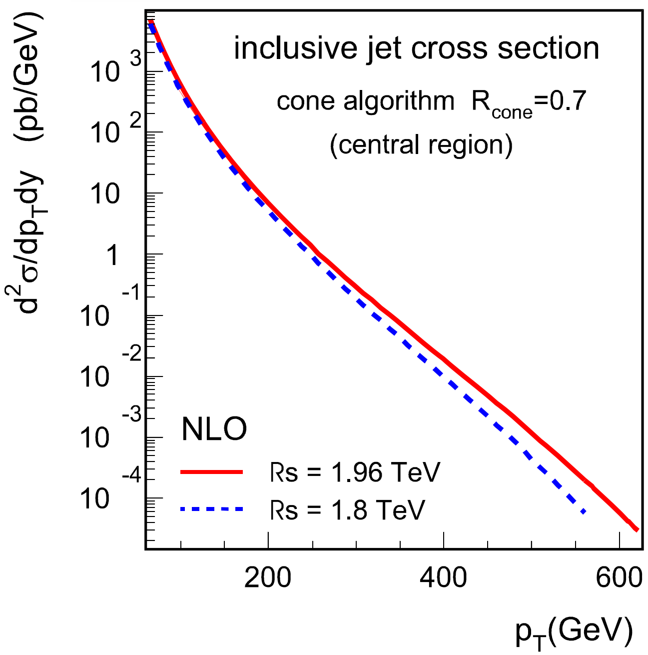
Inclusive Jet Cross Section

Motivation

High p_T jets can test pQCD – inclusive jet cross-section sensitive to α_s and proton PDFs
Deviations could signify new physics

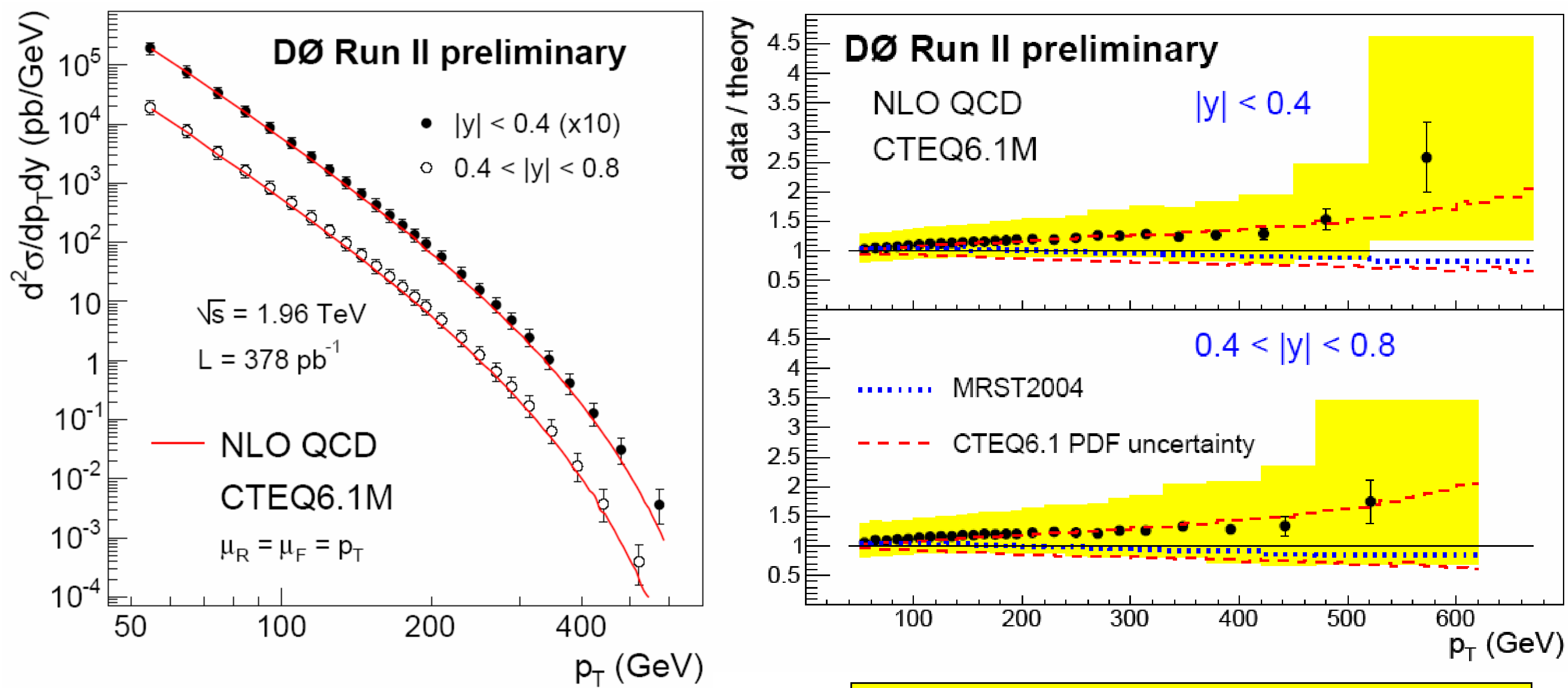


- Low p_T production dominated by gg and qg
- High p_T production dominated by qq
- At 500 GeV ~30% contribution due to qg



Run II $\sqrt{s}$ =1.96 GeV and expect increase of ~300% at 500 GeV in central inclusive jet cross-section as predicted at NLO by CTEQ6.1M PDFs

Inclusive Cross-Section Results



yellow band is total systematic error

Conclusions

- We have determined the JES in all regions of the detector
- The central jet inclusive cross section has been measured using 378pb^{-1} of data
- So far no surprises – data matches NLO predictions within uncertainties
- Results are preliminary, much more luminosity is on the way…